RADIAL ARTERY PULSE CHANGE DURING COLD PRESSOR TEST

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Abstract -Applying cold pressor test (CPT) we see consistent change in the waveform of the radial artery pulses whose shapes are classified into three types according to the peaks and valleys. The second peak is raised during CPT and returns to the original state after finishing immersion. The increase in the second peak is due to the reflected wave.

Key words-**radial artery, waveform, cold pressor test**

.INTRODUCTION

Central aortic pressure and its waveform conveys important information about cardiovascular system. But the measurement of central aortic pressure can be done only invasively. So it has much limitation. To overcome this difficulty, carotid arterial pressure is measured [1]. Chen-han et al. have shown that reasonable estimation can be obtained by applantation of tonometer on the carotid artery. But it is hard to achieve consistent and accurate applantation on the carotid artery because the artery is surrounded by loose tissue[2].

Compared with the carotid arterial pressure pulse measurement, applantation on the radial artery is easier to set up and the required device is also simple using only a pressure sensor and signal conditioner. If the functional aspect of radial arterial pulse is elucidated, the measurement of radial artery pulse would have clinical usefulness.

Cold pressor test(CPT) is a classical test. There are many papers dealing with the physiological change during CPT [3][4][5]. During CPT, sympathetic nervous system is stimulated [3], arteriolar vasoconstriction occurs and blood pressure increases [3][4], and skin blood flow decreases [4]. In some cases CPT is used for the diagnosis of the hand- arm vibration syndrome [6].

In this paper, the change of radial arterial pulse during CPT is investigated, and quantification of these changes is done. The second peak changes due to the reflected wave during CPT as learned from the ref [3].

II. METHODOLOGY

1) *Subject*: Ten healthy subjects were examined. They have no history of cardiovascular disease. Their mean age is 32 year (range from 24 to 56).

2) *CPT:* All subject rested more than 5 min. The base-line was recorded while the subject was seated on the chair for 5 min continuously. (The following procedure is also performed in the same position.) After baseline recording, the right hand and wrist was immersed in the 10 water for 5 min. During immersion, the data was recorded continuously. Soon after hand cooling, the data was also recorded for 5 min (for recovery).

3) *Radial artery pressure wave recording*: Since subjects immersed right hand, the measurement was performed on the left radial artery. Pressure sensor is attached on the left radial artery. The signal is delivered into the signal conditioner, SCXI 1125. The signal passing the signal conditioner enter the PC. Signal can be seen real time. The calculations were executed off-line.

4) *Radial arterial pulse waveform*: The measured radial arterial pulse wave can be classified as following. “Type ”has obvious three peaks and two valleys (Fig. 1). In “type ”, instead of the second peak there is only a shoulder. (Fig. 2). “Type ” has only two peaks and one valley (Fig. 3). After cold pressor test, we saw the consistent arterial pulse change in the waveform.

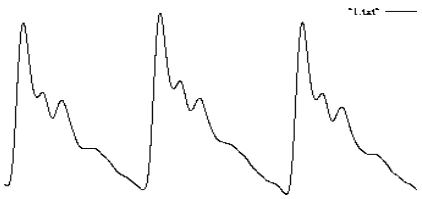

Fig. 1. the radial arterial pulse wave of type

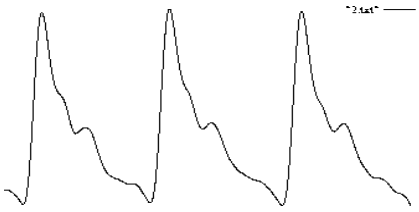

Fig. 2. the radial arterial pulse wave of type

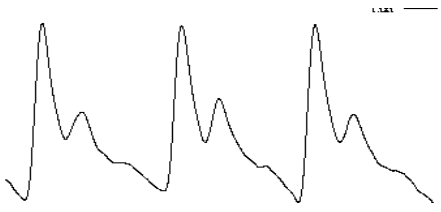

Fig. 3. the radial arterial pulse wave of type

III. RESULTS

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Abstract

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A. Change in waveform

For ten subjects their baseline waveforms are as following according to waveform type. Type is four persons, type is three and type is three.

a. Change in Type

During immersion, in the waveform in type , the height of the second peak is raised. For some subjects, P_2 is almost equal to P_1. For one subject, P_2 is larger than P_1 (Fig.4). After finishing immersion, the waveform recovers original state.

b. Change in Type

In type , the waveform has a shoulder instead of the second peak. During immersion their waveforms turn into Type , i.e. three peaks and two valleys become obvious. After finishing immersion they tend to return to the original states.

c. Change in Type

A subject with type change to the type , while two subjects change to type . We only guess that lowering temperature below 10 would change the latter to the type , but we did not perform this experiment.

B. Heart Rate change

Heart rate (HR) can be obtained using P_1 interval. Heart rate changes differently person by person during CPT. There was no consistent tendency in the heart rate change. It is known that HR during CPT hardly changes [1]. But waveform in all types, have consistent change around the second peak(P_2).

C. Quantifications of change

We tried two ways of quantification of the above change. First the ratio P_2/P_1 is calculated according to the time. Second, the difference between the second peak (P_2) and first valley (V_1) is calculated ($d=P_2-V_1$), and then the ratio d/P_1 is obtained. The values are listed in Tables 1 and 2. During the baseline measurements, the value of P_2/P_1 and d/P_1 does not vary significantly. So we calculated the average. During immersion, the value of and d/P_1 increases up to the maximum and begins to decrease from that moment. So we calculated the maximum during immersion. After finishing immersion, the value of P_2/P_1 and d/P_1 decreases. So we measured them for five minutes, and averaged the value for the last one minute. The tendency of the change of these quantities according to the CPT procedure is also shown in Fig 5.

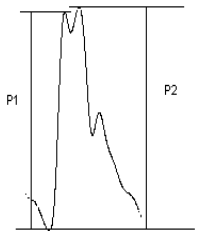

Fig.4 The radial arterial pulse wave change of type during CPT Sometimes the second peak (P_2) becomes larger than the first peak(P_1).

TABLE 1
THE RATIO P_2/P_1 ACCORDING TO THE WAVEFORM(mean ± SD)

Waveform Type	Baseline	During CPT	After
	0.676±0.142	0.988±0.0087	0.700±0.114
	0.534±0.175	0.798±0.09	0.383±0.333
	Non-applicable	0.794±0.10	Non-applicable

SD: standard deviation

TABLE 2
THE RATIO d/P_1 ACCORDING TO THE WAVEFORM (mean ± SD)

Waveform Type	Baseline	During CPT	After
	0.022±0.026	0.233±0.074	0.050±0.025
	0	0.191±0.061	0.006±0.008
	Non-applicable	0.041±0.036	Non-applicable

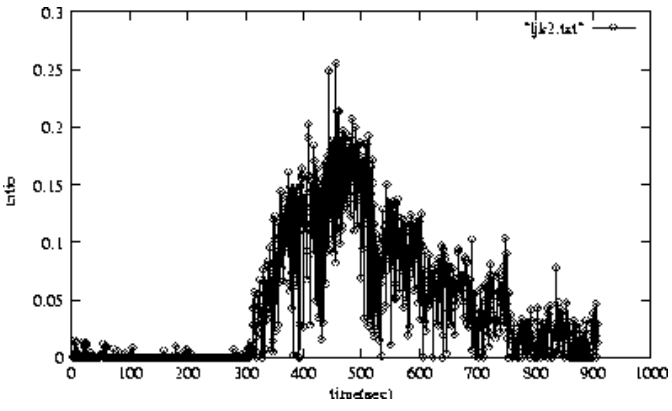

Fig. 5. The ratio of d/P_1 during experiment. This figure is for the type . Before immersion (0-300sec), we could see few second peaks. During immersion (300-600sec) we could see the second peak begins to appear, and increases. After about 450sec, the second peak begins to decrease. After finishing immersion (600-900sec), the second peak decreases. And it shows the tendency to recover the original state.

IV. Discussion

There are some reports about the peripheral system circulation. Some measurements were done on the fingertip [7]. The arterial pulse shape dicrotic notch. The ratio calculated is used as an index representing peripheral arterial resistance[4]. During hand cooling the ratio increases. This change shows that the peripheral arterial resistance also increases. We could say that during CPT, the arterial resistance increase.

There are also several reports about the carotid arterial pressure pulse change during CPT. During CPT the augmentation index changes [3] similar in radial artery. The augmentation index increases. The reason for augmentation index increase is that during CPT the peripheral resistance increase, the arteriolar site of reflection becomes closer to the heart and contribute to enhance the impact of backward pressure [3]. And it is well known during CPT, the blood pressure becomes high [3][4]. As blood pressure increase, the pulse wave velocity would increase, and could affect the enhancement of reflection wave.

In our experiment, the second peaks(P_2) are raised in Type . In Type , obscure second peaks become obvious. In Type , the waveform has no second peak before CPT, but it becomes type during immersion. Using these change around the second peaks during CPT, we could infer that the reflected wave affect the waveforms to increase the second peak as learned from ref [3].

V. Conclusion

In this experiment, we could see the consistent change in radial artery pulse during CPT. The second peak raised during CPT, and this change is quantified by comparing with the first peak and the second peak. The reason for the raising of the second peak could be the enhanced reflected wave.

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References

[1] C.H. Chen, C.T. Ting, A. Nussbacher, E. Nevo, D. A. Kass, P. Pak, S. P. Wang, M. S Chang, C.P. Frank, "Validation of Carotid Artery Tonometry as a Means of Estimating Augmentation Index of Ascending Aortic Pressure", *Hypertension*, 1996;27:168-175

[2] C.H. Chen, E. Nevo, B. Fetics, H. Peter, F. C.P. Yin, W. L. Maughan,s D. A. Kass "Estimation of Central Aortic Pressure Waveform by Mathematical Transformation of Radial Tonometry Pressure" *Circulation*, 1997;95:1827-1836

[3] A. B. Lavleche, B. M. Pannier, B. Laloux and M. E. Safar "Arterial response during cold pressor test in borderline hypertension." *Am. J. Physiol*. 275(Heart Circ. Physiol. 44): H409-H415, 1998.

[4] S. Sundberg, M. Castrén, " Drug- and temperature-induced changes in peripheral ciculation measured by laser-Doppler flowmetry and digital-pulse plethysmography." *Scand. J. Clin. Lab. Inves*t 46:359-365(1986)
s72:330-334 (1999)

[5] P. Haapalahti, M. Mäkijärvi, P. Korhonen, P. Talaka, J. Montonen, Y. Salorinne, L. Oikarinen, M. Viitasalo, L. Toivonen "Magnetocardiography QT dispersion during cardiovascular autonomic function tests." *Basic Res. Cardiol*. 95: 424-430(2000)

[6]N. Harada, M. Yoshimura, M. S. Laskar "A minireview of studies conducted in Japan using finger-skin temperature during cold stress tests for the diagnosis of hand arm vibration syndrome." *Int. Arch. Occup. Environ. Health* 72:330-334 (1999)

[7] T. O. Klemsdal, H. H. Mundal, K. Gjesdal, "Effect of carfedilol and atenolol on the arterial pulse curves (plethysmography) and finger temperature after hand cooling." *E. J. Clin. Parmacol.*(1996) 50: 483-489

[8] Y.Z. Yoon, M.H. Lee, H. S. Shin, K.S. Soh, "Contrivance of a radial pulse measuring system with variable contact pressure", *J. Biomed. Eng. Res,* vol. 20, pp. 567-572, 1999

[9] M.H. Lee, K. P. Kwon, Y. Z. Yoon, K.S. Soh, "The effect of exercise on the fractal characteristics of arterial pulse signal" unpublished